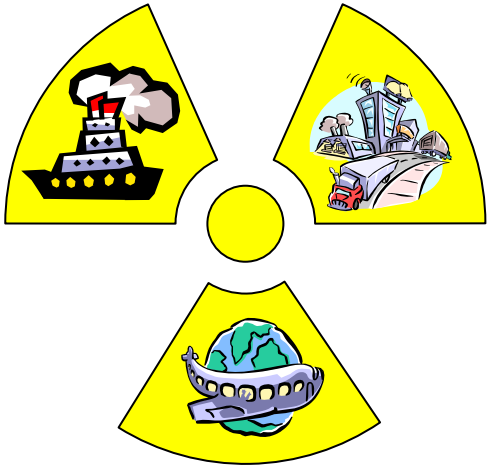
Shipment of nuclear material



by Corinne Brossard

14.04.2005

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

Presentation of the classification of a shipment of nuclear material with

Legislation:

- Local Regulations

  License of the consignee
  License of the shipper

- National and European Regulations

  Atomic act
  Ionising Radiation Regulations
  Export Control Regulations
  Custom Regulations

- International Regulations

  IATA-Regulations for air transports
  ADR-Regulations for road/ train/see transports

Definitions:

- Radioactive Materials:

Radioactive materials are articles or substances which spontaneously and continuously emit certain types of radiation (ionizing radiation) which can be harmful to health

- Fissile Materials:

Fissile materials are certain radioactive material in which the atoms are capable of being split by neutron radiation, thereby producing fission products and releasing energy in form of heat, gamma radiation and further neutron radiation

- Fissile-excepted:

Less than 15 g as Fissile Material

What is the Classification?

The choice of the container you will use to transport the material

The definition of the UN-Number and
of the proper shipping name

Activity limits for the packages:

Excepted packages:

Nature of contents	Materials	Instruments and articles	
	Packages limits	Item limits	Package limits
Solids			
Special form	10^{-3} A_1	10^{-2} A_1	A_1
Other forms	10^{-3} A_2	10^{-2} A_2	A_2
Liquids	10^{-4} A_2	10^{-3} A_2	10^{-1} A_2
Gases			
Tritium	2.10^{-2} A_2	2.10^{-2} A_2	2.10^{-1} A_2
Special form	10^{-3} A_1	10^{-3} A_1	10^{-2} A_1
Other forms	10^{-3} A_2	10^{-3} A_2	10^{-2} A_2

Table 2.2.7.7.1.2.1 “Activity limits for excepted packages” ADR

Activity limits for the packages:

Type A Packages:

$\frac{A}{A_1} \leq 1$ for special form of radioactive material; or

$\frac{A}{A_2} \leq 1$ for all other radioactive materials

Type B(U) and B(M) Packages:

The package design given the activity limits,
the authorised form and physical and chemical state

Where are the A_1 and A_2 values?

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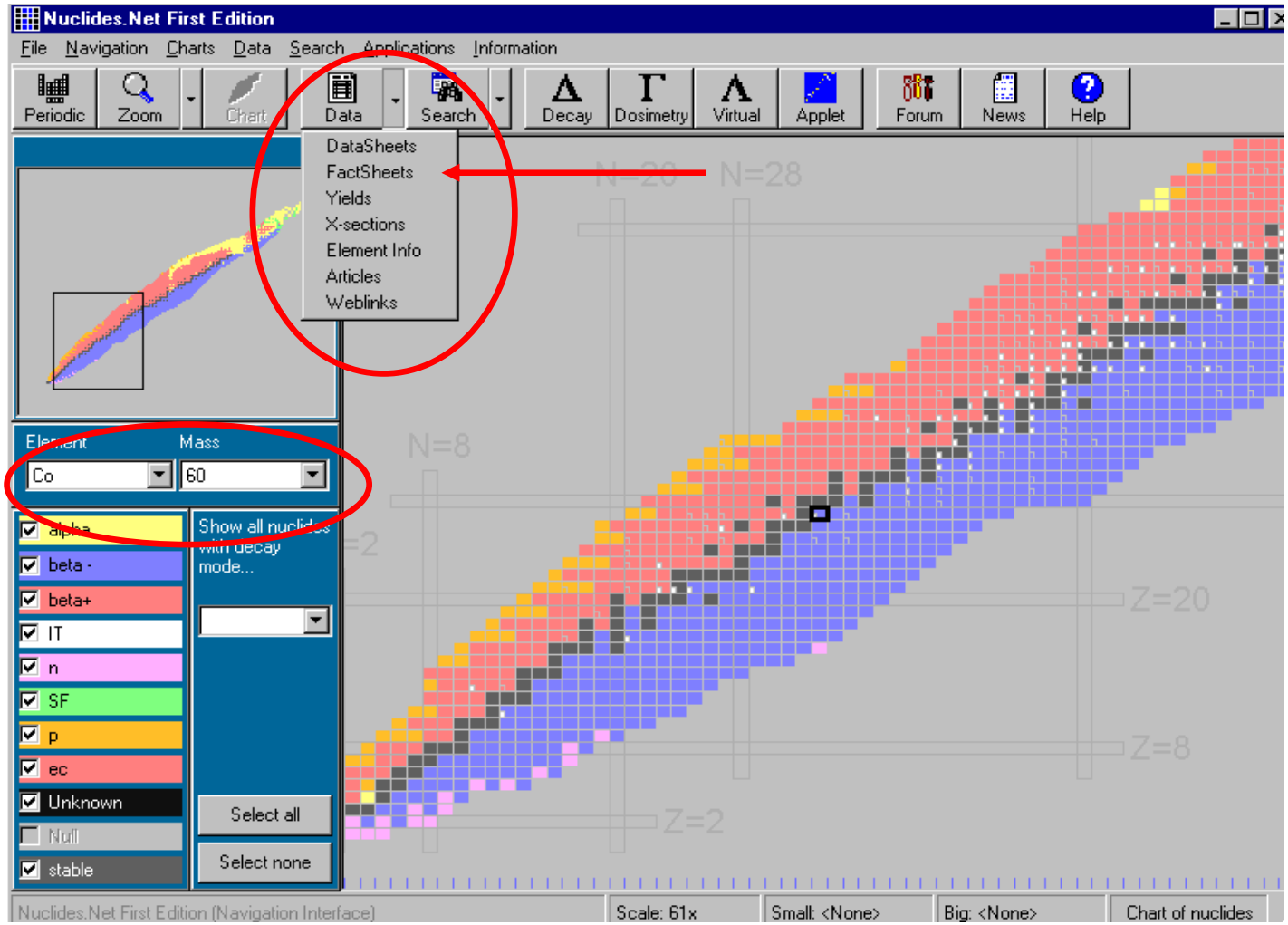

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Nuclide : ^{60}Co

Half-Life =	5.28E+00	y
Average or mean lifetime =	7.6E+00	y
Specific Activity =	4.19E+13	Bq/g
Heat Generation:		
Isotopic Power(α) =	0.0E+00	W/g
Isotopic Power(α+β) =	6.47E-01	W/g
Isotopic Power(α+β+γ) =	1.74E+01	W/g
Gamma Emission:		
Specific Gamma Dose Rate at 1m.=	3.37E-01	µSv/MBq.h
Radiotoxicity:		
Annual Limit of Intake (ALI) for Inhalation* =	6.9E+05	Bq
Annual Limit of Intake (ALI) for Ingestion* =	5.88E+06	Bq
Derived air concentration (DAC)* =	2.87E+02	Bq/m^3
Derived water concentration (DWC)* =	6.44E+03	Bq/litre
Packaging & Transport:		
Activity limits for special form materials, A1 =	0.4	TBq
Activity limits for normal form materials, A2 =	0.4	TBq
Mass(A1) =	9.55E-15	g
Mass(A2) =	9.55E-15	g

*Based on Reference Annual Dose: 0,02 Sv for workers. For members of the public, the reference annual dose is 1mSv and these numbers should be reduced by a factor 20.

Calculation:

- Take the activity (A) from each nuclide included in the material

- Looking for the A_1 / A_2 value of these nuclides

Calculation:

for one nuclide:

$$\frac{A}{A_1}$$ For special form of material

$$\frac{A}{A_2}$$ For other material

for more nuclides:

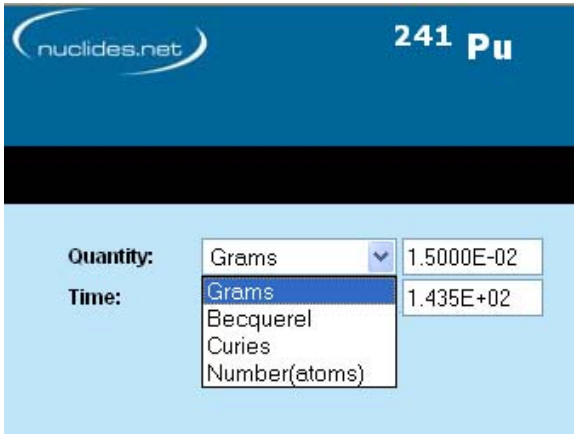
$$\sum \frac{A}{A_1}$$ For special form of material

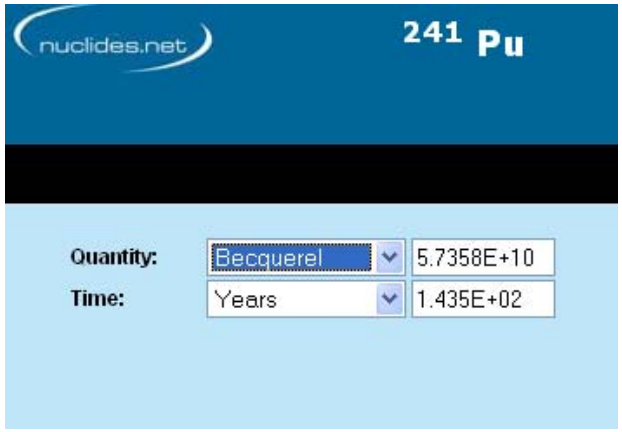
$$\sum \frac{A}{A_2}$$ For other material

Example:

1 sample of :
- Pu-241
- 15 mg
- 8 years old
- Solid
- Non special form

1st step: Calculate the activity of Pu-241





2nd step: The A2 Value of the Pu-241

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Nuclide : ^{241}Pu

Half-Life =	1.44E+01	y
Average or mean lifetime =	2.07E+01	y
Specific Activity =	3.82E+12	Bq/g
Heat Generation:		
Isotopic Power(α) =	7.34E-05	W/g
Isotopic Power(α+β) =	3.28E-03	W/g
Isotopic Power(α+β+γ) =	3.28E-03	W/g
Neutron Emission:		
Spontaneous Fission Rate =	9.18E-04	$g^{-1}.s^{-1}$
Gamma Emission:		
Specific Gamma Dose Rate at 1m.=	5.51E-06	µSv/MBq.h
Radiotoxicity:		
Annual Limit of Intake (ALI) for Inhalation* =	2.35E+04	Bq
Annual Limit of Intake (ALI) for Ingestion* =	4.17E+06	Bq
Derived air concentration (DAC)* =	9.8E+00	Bq/m^3
Derived water concentration (DWC)* =	4.56E+03	Bq/litre
Packaging & Transport:		
Activity limits for special form materials, A1 =	40	TBq
Activity limits for normal form materials, A2 =	0.06	TBq
Mass(A1) =	1.05E-11	g
Mass(A2) =	1.57E-14	g

*Based on Reference Annual Dose: 0,02 Sv for workers. For members of the public, the reference annual dose is 1mSv and these numbers should be reduced by a factor 20.

3rd step: Calculate the ratio A/A_2

$$\frac{A}{A_2} = \frac{5.74 \cdot 10^{10}}{60 \cdot 10^{9}} = 0.96 < 1$$

Example:

Remember:

Excepted package:

Nature of contents	Materials	Instruments and articles	
	Packages limits	Item limits	Package limits
Solids			
Special form	10^{-3} A_1	10^{-2} A_1	A_1
Other forms	10^{-3} A_2	10^{-2} A_2	A_2
Liquids	10^{-4} A_2	10^{-3} A_2	10^{-1} A_2
Gases			
Tritium	2.10^{-2} A_2	2.10^{-2} A_2	2.10^{-1} A_2
Special form	10^{-3} A_1	10^{-3} A_1	10^{-2} A_1
Other forms	10^{-3} A_2	10^{-3} A_2	10^{-2} A_2

Table 2.2.7.7.1.2.1 “Activity limits for excepted packages” ADR

Type A Package: $\frac{A}{A_2} < 1$

Type B Package: $\frac{A}{A_2} > 1$

For other material
(non special Form)

Example:

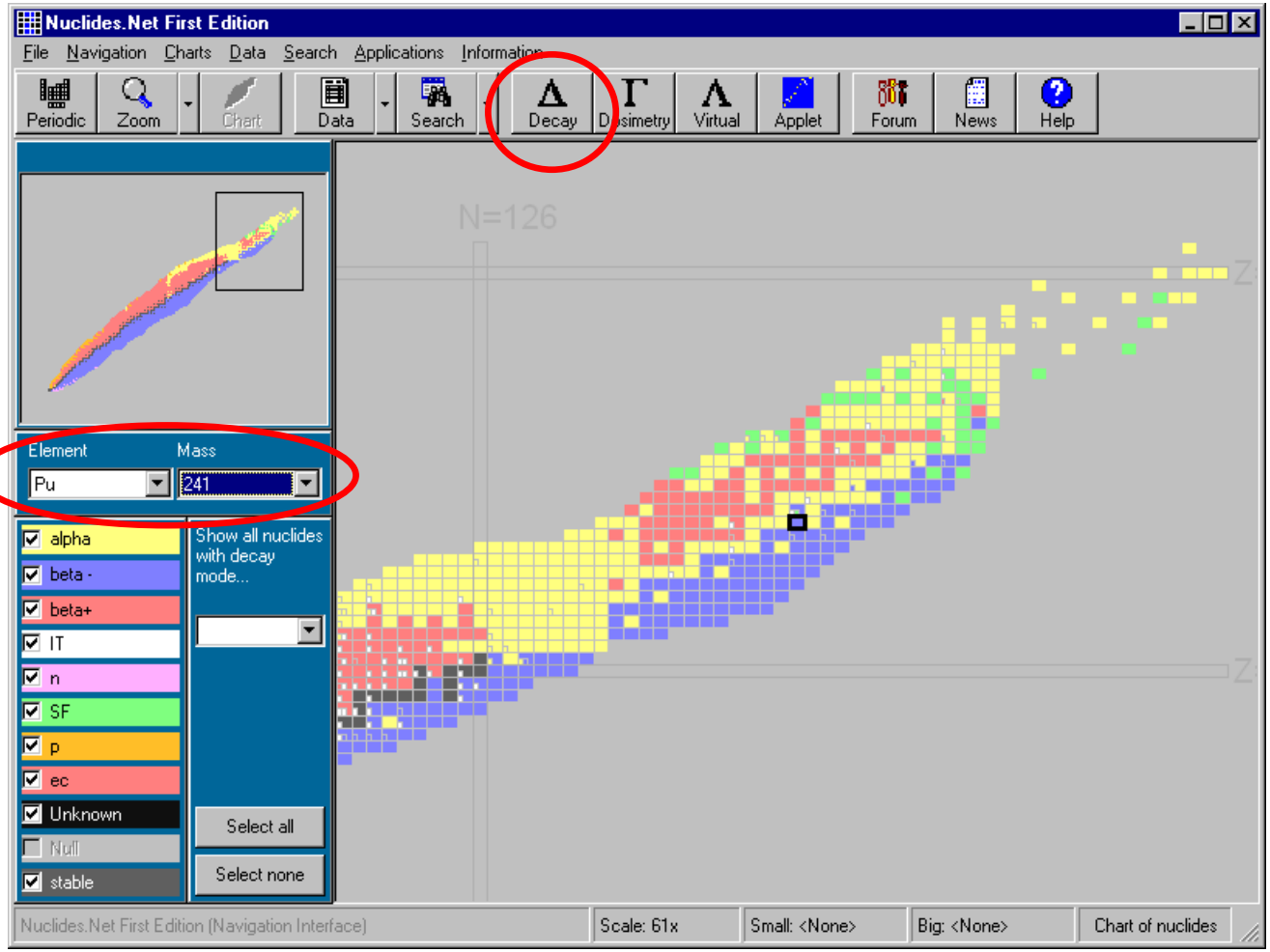
3rd step: Calculate the ratio A/A_2

$$\frac{A}{A_2} = \frac{5.74 \cdot 10^{10}}{60 \cdot 10^{9}} = 0.96 < 1$$

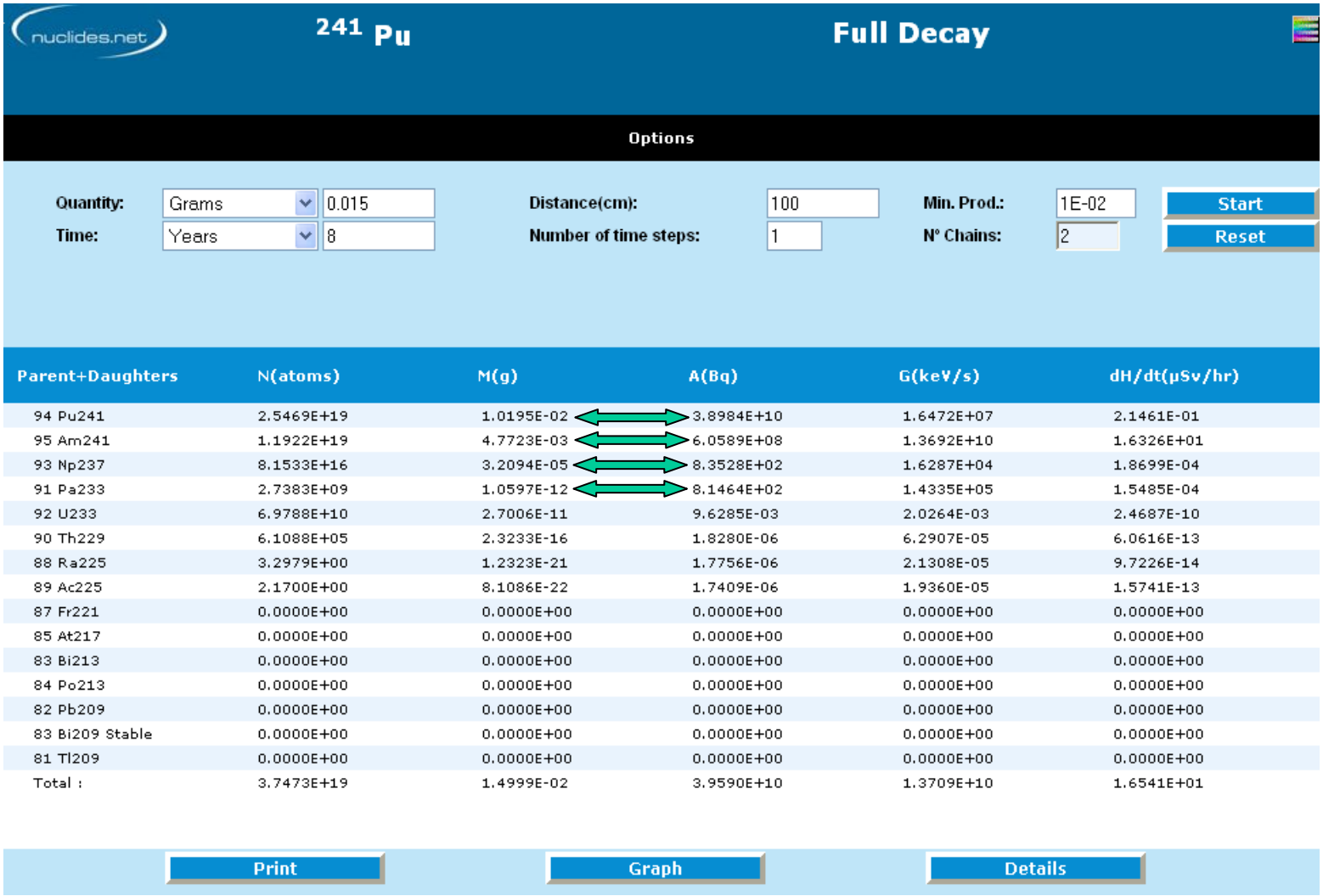
We could use a type A container

Example:

Warning: with the decay of the Pu-241



Example:



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241 Pu — **Full Decay**

Options

Quantity:	Grams	0.015	**Distance(cm):**	100	**Min. Prod.:**	1E-02	Start
Time:	Years	8	**Number of time steps:**	1	**N° Chains:**	2	Reset

Parent+Daughters	N(atoms)	M(g)	A(Bq)	G(keV/s)	dH/dt(µSv/hr)
94 Pu241	2.5469E+19	1.0195E-02	3.8984E+10	1.6472E+07	2.1461E-01
95 Am241	1.1922E+19	4.7723E-03	6.0589E+08	1.3692E+10	1.6326E+01
93 Np237	8.1533E+16	3.2094E-05	8.3528E+02	1.6287E+04	1.8699E-04
91 Pa233	2.7383E+09	1.0597E-12	8.1464E+02	1.4335E+05	1.5485E-04
92 U233	6.9788E+10	2.7006E-11	9.6285E-03	2.0264E-03	2.4687E-10
90 Th229	6.1088E+05	2.3233E-16	1.8280E-06	6.2907E-05	6.0616E-13
88 Ra225	3.2979E+00	1.2323E-21	1.7756E-06	2.1308E-05	9.7226E-14
89 Ac225	2.1700E+00	8.1086E-22	1.7409E-06	1.9360E-05	1.5741E-13
87 Fr221	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
85 At217	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
83 Bi213	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
84 Po213	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
82 Pb209	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
83 Bi209 Stable	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
81 Tl209	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Total :	3.7473E+19	1.4999E-02	3.9590E+10	1.3709E+10	1.6541E+01

Print Graph Details

Example:

Summery

	Activity [Bq]	A_2 [Bq]
Pu-241	3,9 E+10	60 E+9
Am-241	6,05 E+8	1 E+9
Np-237	835	2 E+9
Pa-233	815	700 E+9

Example:

3rd Step: Calculation of A_2 rate

$$\frac{A_{Pu-241}}{A2_{Pu-241}} + \frac{A_{Am-241}}{A2_{Am-241}} + \frac{A_{Np-237}}{A2_{Np-237}} + \frac{A_{Pa-233}}{A2_{Pa-233}}$$

$$\frac{3.9 \cdot 10^{10}}{60 \cdot 10^{9}} + \frac{6.05 \cdot 10^{8}}{1 \cdot 10^{9}} + \frac{835}{2 \cdot 10^{9}} + \frac{815}{7 \cdot 10^{11}} = \quad 1{,}2$$

Example:

Remember:

Excepted package:

Nature of contents	Materials	Instruments and articles	
	Packages limits	Item limits	Package limits
Solids			
Special form	10^{-3} A_1	10^{-2} A_1	A_1
Other forms	10^{-3} A_2	10^{-2} A_2	A_2
Liquids	10^{-4} A_2	10^{-3} A_2	10^{-1} A_2
Gases			
Tritium	2.10^{-2} A_2	2.10^{-2} A_2	2.10^{-1} A_2
Special form	10^{-3} A_1	10^{-3} A_1	10^{-2} A_1
Other forms	10^{-3} A_2	10^{-3} A_2	10^{-2} A_2

Table 2.2.7.7.1.2.1 “Activity limits for excepted packages” ADR

Type A Package: $\frac{A}{A_2} < 1$

Type B Package: $\frac{A}{A_2} > 1$

For other material
(non special Form)

Example:

In this case: $\frac{A}{A_2} = 1.2$

$$\frac{A}{A_2} > 1$$

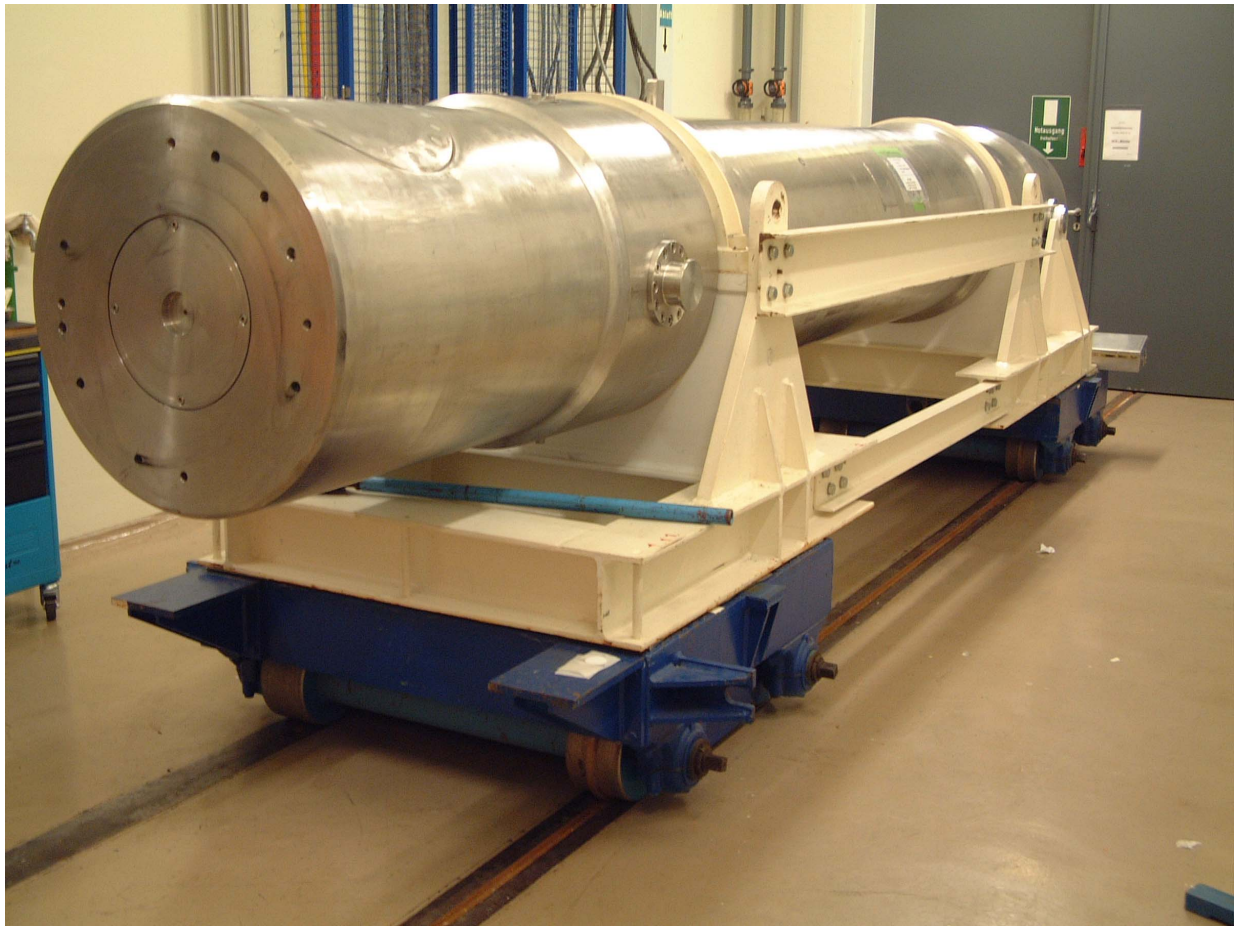
We have to use a type B container

Some containers:

Croft 2799 B(U)-96

R 52

R 52



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